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Editorial

Editorial of the Special Issue "Anaerobic Co-Digestion of Lignocellulosic Wastes"

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1. Introduction

Carbohydrates from vegetal biomass (wood and agricultural biomass) are the focus of biorefinery strategies [1]. In the search for a cheap, widespread and available carbon source not related to the food market (second generation biomass), all efforts have been focused on lignocellulosic biomass as the main substrate. However, lignocellulosic structures are difficult to depolymerize and pretreatments are needed in order to access the readily degradable carbon.

On the other hand, anaerobic digestion is a technologically mature microbial process which has been considered as a theoretically carbon-neutral process when vegetal biomass is used as a substrate. Even a substantial reduction of greenhouse gases impact is possible if natural and decontrolled anaerobic decomposition is considered as the usual fate of some types of waste (e.g., animal manures or forestry residuals) [2]. In this issue, Muhayodin et al. [3] present a global study about the applicability of anaerobic digestion as a process for reducing the greenhouse gases from rice straw as an example of lignocellulosic material including a mass balance for nutrients. The anaerobic digestion of rice straw is a clear case of reducing the impact of greenhouse gases. In data extracted from Scival®, the *anaerobic digestion/digester/methane production* topic (T155) is ranked 7th of 1621 topics in the *Environmental engineering* subject by prominence index based on Citation count, Scopus view count and average CiteScore, with a percentile of 99.937 [4].

In the present Special Issue, a collection of research and review papers has been presented for the discussion of the possibilities of anaerobic co-digestion of lignocellulosic biomass for bioenergy production with a special emphasis on the pretreatment of biomass to enhance the biodegradability and the subsequent biogas production. Five reviews have been included to provide a full dimension of the topic.

2. Pretreatments in the Hotspot

As a reflection of the clear interest in pretreatment procedures for the improvement of the anaerobic digestion of lignocellulosic biomass, the first half of the papers in the Special Issue are related to pretreatments. The reviews by Sayara et al. [5] and Hernández-Beltrán et al. [6] contribute with an overview on the possible types of pretreatment and the subsequent conditions of the anaerobic digestion process for biogas production. In addition, the latter paper includes a techno-economic and environmental analysis. Acid pretreatment is a highly effective chemical technique used to disrupt the lignocellulosic matrix by cleavage of glucosidic bonds, where mild acid pretreatments are the most promising technology [7]. Sorghum stalks from sixteen representative pedigreed sorghum mutant lines were tested by Xu et al. [8] with a classical diluted acid pretreatment as a previous step for enzymatic saccharification. The authors obtained a glucose recovery of 80–85% from cellulose and hemicellulose with minimal degradation products, proposing a pre-washing step where water-extractive content exceeded 35% (*w/w*), before being subjected to the acid pretreatment process in order to avoid sugar losses or degradation. Furthermore, an effective option is the organosolv pretreatment, which Sulbarán-Rangel et al. [9] verified using corncob wastes. The organosolv process is a thermochemical delignification process that consists of breaking the internal lignin and hemicellulose bonds of the lignocellulosic material with solvents. In this case, ethanol/acetic acid (1:10) was applied as organosolv reagent to obtain the hydrolysates. Improvement in biogas production was four times greater in the batch test. As a common co-substrate, animal manures are particulate organic-rich materials with negative effects on the kinetics of the anaerobic process. The effect of enzymatic (cellulase) pretreatment on particulate disintegration of this waste was studied by Tassew et al. [10]. Moreover, the review by Ahmed et al. [11] offers an in-depth insight into hydrothermal pretreatment with a section dedicated to inhibitors formed by the delignification process (mainly furfural and 5-HMF) and strategies to overcome it.

3. Anaerobic Co-Digestion Process

Aboudi et al. [12] presented a study of the mesophilic anaerobic co-digestion of lignocellulosic material (exhausted sugar beet pulp) with animal manures (pig and cow) in reactors fed in semi-continuous mode. This mixture shows the huge potential of co-substrates to improve the methane yield (70 and 31% increase in methane production, respectively) by mitigating the inhibitory effect of volatile fatty acids at high loading rate conditions. The tests were analyzed from a novel perspective, evaluating the uncoupling of anaerobic phases (hydrolysis, acidogenesis/acetogenesis and methanogenesis) through the calculation of indirect carbon-related parameters such as acidogenic substrate carbon (ASC). In the same way, Gómez-Quiroga et al. [13] refer to a similar study with the same type of lignocellulosic material (exhausted sugar beet pulp) under thermophilic operating conditions, where batch tests were assayed, showing that the activity of acetoclastic methanogens was especially affected at thermophilic conditions while organic matter solubilization was more efficient. As a final colophon, the review of Sarker et al. [14] focuses on the different types of bioreactors and configurations for the anaerobic process.

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